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Contents

	Page
Editorial	2
Effect Of A Number Of Variables On A Quality Characteristic	3
Statistical Quality Control: What It Is and What It Does	6
Society of Quality Control Engineers In Michigan	11
Midwest Quality Control Conference	12
Quality Control Engineers Of Rochester	14
Society Reports	16
Society Of Quality Control Engineers Of Buffalo	18
Bibliography	19

SOCIETY OF QUALITY CONTROL ENGINEERS
IN COOPERATION WITH
THE UNIVERSITY OF BUFFALO

INDUSTRIAL QUALITY CONTROL
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Buffalo 14, New York

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EDITORIAL

February 16

Your editor vowed to himself some months ago that he would not in the future discuss on this page the matter of the formation of a nationwide quality control society. That vow is broken in this editorial because of a most encouraging new development which should come to the attention of each subscriber without delay. Arrangements for a new nation-wide organization have recently been completed and are now ready for general announcement. February 16 representatives of all of the organized local societies and recognized industrial quality control leaders will meet in New York to launch the new Society. The meeting will be called to order at 9:00 a.m. at the Edison Electric Institute. For the first time I am able to say to you that every subscriber to this magazine is more than welcome to attend the meeting. Immediately it must be stated that, if 1,000 of you attend, the meeting accommodations will be hopelessly inadequate, but all who reside in the New York area or may be visiting there on February 16 will be welcome.

A constitution has been drafted and it is the intention of all concerned that this constitution, in its present form or properly amended, shall be adopted at the meeting. The delegates will then proceed with the election of the officers provided for in the constitution. These are, President, Vice-President, Secretary, and Treasurer. The Executive Board will be composed of a representative of each local quality control society which is a member of the nationwide organization. The affairs of the organization will be in the hands of the officers and the Executive Board.

The constitution provides for voting on the basis of the number of members in good standing in each local member society. This plan will be employed in the February 16 meeting in order to insure an orderly balloting procedure and to facilitate the transaction of the business at hand.

The constitution also provides for the appointment by the President and the Executive Board of an Editorial Board which will be responsible for the publication of a journal to be supplied to all members of the Society. Present plans call for INDUSTRIAL QUALITY CONTROL to become the publication of the new Society. The Federated Societies (Detroit, Rochester, Syracuse, and Buffalo) have approved this transfer on the following conditions: (1) that the organization is established as planned on February 16; (2) that all unfulfilled subscription obligations be assumed by the new Society and that copies of issues of the magazine be supplied to you until the end of your present subscription; (3) that all assets and liabilities of the magazine shall be taken over by the new Society.

This means that the magazine will have a larger circulation and correspondingly a greater income than at present. With more margin on which to work, the Editorial Board will be able to put into effect enlargement and improvements which have been mere pious hopes up to this point.

Actually this is a preliminary report. I have every confidence that the February 16 meeting will bring forth a new Society which is fully representative of the quality control work which is being done in the United States and in Canada. However, should these plans fail to materialize as expected, INDUSTRIAL QUALITY CONTROL is prepared to go forward along the lines followed during the first year and one half of its existence. A full report of the proceedings of the February 16 meeting will be presented in the March issue of the magazine.

TREND

Shortly after the end of the war it became apparent that many of the quality control installations inaugurated during the war would not survive the reconversion phase. At one point the thinking of management seemed to be concentrated on recreating pre-war conditions of manufacture. Recently concrete evidence is at hand to show that the trend of management thinking has been reversed. As plant after plant has reached the production stage on post-war products, the old story of assembly rejection, failure to function, and inability to meet customers' tests has reappeared. But this time management has stepped in to put the wartime trouble shooter back on the job.

The Effect Of A Number Of Variables On A Quality Characteristic

CASPER GOFFMAN

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The manufacturing engineer is constantly confronted with situations where a process is affected by a number of variable factors. It is his desire, in such cases, to know how great the effect of each variable can be if its variability is over the entire range which can be expected in normal production. For purposes of proper orientation, we mention a few examples. In a foundry, the hardness of castings may be influenced by the carbon and silicon content, pouring temperature, blast velocity and numerous other factors. In the manufacture of lightning arrester blocks, the volt-ampere characteristics are affected by molding pressure, baking temperature, time of aging, etc. In applying insulation to copper wire, important variables affecting the insulation characteristics are baking temperature, baking time, and viscosity of applied enamel. In preparing material for molding plastic parts, the rolling temperature, rolling time, and percentages of ingredients of the mixture all influence the physical characteristics of the material. These examples are but an indication of the wide variety of manufactured items to which the type of analysis we shall discuss can be applied. Indeed, practically any manufacturing process may be used as an example.

The usual approach to this sort of problem by the engineer may be designated as the method of isolating factors. If there are several factors which can influence the quality characteristic under consideration, attention is focused on each one separately by holding all others as constant as possible while varying the factor being studied over the desired range. The results are then plotted with the variable factor as abscissa and the quality characteristic as ordinate, and a curve drawn which is a best fit to the data in some sense. This method is commendable, and if diligently pursued will give the desired information.

However, this method has several drawbacks. Indeed, it generally happens that the effect of the isolated factor varies with the choice of the constant values at which the other factors are held. For example, the detergency of a certain washing agent is affected more strongly by concentration at low temperatures than at higher temperatures. Hence, in using the method of isolating factors, in order to get a true picture of the effect of the isolated factor, a family of curves must generally be obtained for various possible values of the constant factors. This leads to problems of interpretation of data.

Especially in a large organization, it is desirable to have a systematic plan for collecting and analyzing data of this type. The method we present has appealed to our engineers for its simplicity, ease of calculation, and the fact that it gives the kind of information the engineer wishes to have. Essentially, it gives the average effect of each factor on the quality characteristic, where the other factors considered vary over a predetermined range.

We illustrate the procedure by data obtained for the detergency (washing characteristics) of a certain detergent (soap). We wish to study the effect of washing time, washing temperature, and concentration of washing agents on detergency. The detergency at a given time, temperature, and concentration is determined by means of reflectance before and after washing of a standard soil sample. In the experiment, washing times of 5, 10, and 15 minutes; temperatures of 100° F., 120° F., and 140° F.; and concentrations of .10%, .20%, .30%, and .40% were used. Samples were washed at every possible combination of the above times, temperatures, and concentrations. It should be noted that the times, temperatures, and concentrations used are equally spaced; the difference between successive times being 5 minutes, the difference between successive temperatures 20° F., and the difference between successive concentrations .10%. **The method given here applies only when values used for the variable factors are equally spaced.** Otherwise the calculation becomes cumbersome. Generally, it is easy to meet this condition in practice.

The numbers appearing in Table I represent the detergency at the given times, temperatures, and concentrations. For example, at 10 minutes, 140° F., and .30% concentration, the detergency is 98.

As a first step we calculate the average of the 36 observations of detergency appearing in Table I. In this case, the average is 72.

We then obtain Table II.

Briefly, the numbers in Table II are deviations from the average. For example, the average time for all observations is 10 minutes. Hence, 5 minutes in Table I becomes 5 − 10 = −5 minutes in Table II. The average concentration for all observations is .25%. Hence, .10% in Table I becomes .10 − .25 = −.15% in Table II, and .30% in Table I becomes .30 − .25 = .05% in Table II. The average detergency is 72. Hence, 37 in Table I becomes 37 − 72 = −35 in Table II and 115 in Table I becomes 115 − 72 = 43 in Table II.

(Continued on Page 4)

TABLE I

Detergency of Detergent A at Various Times, Temperatures, Concentrations

Temp. (T)	Conc. (c)	Time (t) 5 min.	10 min.	15 min.
			Detergency (D)	
100° F.	.10%	37	39	43
	.20%	42	45	47
	.30%	46	53	55
	.40%	48	56	63
120° F.	.10%	53	61	68
	.20%	62	74	79
	.30%	79	84	92
	.40%	84	96	104
140° F.	.10%	59	68	71
	.20%	74	82	89
	.30%	88	98	115
	.40%	102	123	122

TABLE II

Deviations of the Detergency Values from their Average, with Time, Temperature, and Concentration Variables Expressed as Variations from their Respective Midvalues

Temp.	Conc.	Time −5	0	5
			Detergency	
−20	−.15	−35	−33	−29
	−.05	−30	−27	−25
	+.05	−26	−19	−17
	+.15	−24	−16	− 9
0	−.15	−19	−11	− 4
	−.05	−10	+ 2	+ 7
	+.05	+ 7	+12	+20
	+.15	+12	+24	+32
20	−.15	−13	− 4	− 1
	−.05	+ 2	+10	+17
	+.05	+16	+26	+43
	+.15	+30	+51	+50

We now use Table II to calculate the effect of each of the three variables — time, temperature, and concentration — on detergency. Consider first the effect of time. The calculation may be made in three steps.

1. Multiply each detergency value by the associated time value. The associated time value for every detergency value in the first column is −5. The associated time value for every detergency value in the second column is 0. The associated time value for every detergency value in the third column is +5. Add the products obtained algebraically. The answer is 870.

2. Take the sum of squares of the associated time values. For 12 of the observations the associated time value is −5; the associated time value is 0 for 12 other observations and +5 for the remaining 12 observations. Hence, the answer is

$$12 \times (-5)^2 + 12 \times (0^2) + 12 \times (+5)^2 = 300 + 0 + 300 = 600.$$

3. Divide the answer in 1. by the answer in 2. In this case, 870 ÷ 600 = 1.45. The figure 1.45 is a measure of the effect of time variation on detergency variation. A change of 1 minute in washing time produces a change of 1.45 units in detergency.

By a similar calculation with respect to temperature and concentration, we find that changes of 1° F. in temperature and 1% in soap concentration result respectively in changes of 1.11 units and 112 units in detergency.

These three numbers are the essence of the data. In statistics, they are called the coefficients of partial regression with respect to time, temperature, and concentration, respectively. Using these coefficients we obtain the regression equation:

$$D' = 1.45\,t + 1.11\,T + 112\,c$$

where D', t, T and c are respectively the detergency, time, temperature, and concentration. This equation is the best fit to the data of Table II.

It is generally desirable to test whether a coefficient of partial regression is significant. By this we mean — could the value obtained be due to chance while the true value is 0? In particular, how likely is it that detergency does not depend upon time at all and the results we obtained are just due to the fact that we only have taken a small number of observations.

For the interested reader, we now give a technique for answering this question. In Table III, Column 1 gives the observed detergencies D, and Column 2 the corresponding detergencies D' calculated from the regression equation. For example, for t = −5, T = −20, and c = −.15, Table II shows D = −35. From the regression equation,

$$D' = 1.45(-5) + 1.11(-20) + 112(-.15) = 46.25.$$

We shall disregard the figures to the right of the decimal point.

TABLE III

D	D'	D-D'	(D-D')2
−35	−46	+11	121
−30	−35	+ 5	25
−26	−24	− 2	4
−24	−13	−11	121
−19	−24	+ 5	25
−10	−13	+ 3	9
+ 7	− 2	+ 9	81
+12	+10	+ 2	4
−13	− 2	−11	121
+ 2	+ 9	− 7	49
+16	+20	− 4	16
+30	+32	− 2	4
−33	−39	+ 6	36
−27	−28	+ 1	1
−19	−17	− 2	4
−16	− 5	−11	121
−11	−17	+ 6	36
+ 2	− 6	+ 8	64
+12	+ 6	+ 6	36
+24	+17	+ 7	49
− 4	+ 5	− 9	81
+10	+17	− 7	49
+26	+28	− 2	4
+51	+39	+12	144
−29	−32	+ 3	9
−25	−20	− 5	25
−17	− 9	− 8	64
− 9	+ 2	−11	121
− 4	− 8	+ 4	16
+ 7	+ 2	+ 5	25
+20	+13	+ 7	49
+32	+24	+ 8	64
− 1	+13	−14	196
+17	+24	− 7	49
+43	+35	+ 8	64
+50	+46	+ 4	16
		Σ (D-D')2 = 1903	

The figure in the third column of Table III is the difference between the figures in the first and second columns. The figure in the fourth column is the square of the figure in the third column. The number

$\Sigma (D-D')^2$ is the sum of the entries in the fourth column. In this case, $\Sigma(D-D')^2 = 1903$.

To decide whether the coefficient of partial regression with respect to time, for example, is significant we calculate the statistic t defined as follows:

$$t = \frac{r_t}{\sqrt{\frac{1}{V_t}\frac{\Sigma (D-D')^2}{n-k-1}}}$$

where $r_t = 1.45$ is the coefficient of partial regression with respect to time, $V_t = 600$ is the sum of squares of associated time values, $n = 36$ is the number of observations on D, and k is the number of independent variables (in this case, time, temperature and concentration). The number $n - k - 1 = 32$ is known as the number of degrees of freedom. Substituting these values in the formula for t, we have:

$$t = \frac{1.45}{\sqrt{\frac{1}{600}\frac{1903}{32}}} = 4.61$$

For general purposes, if t exceeds the value for the .01 probability level, the difference is considered to be significant. Referring to Table IV, we see that the .01 probability level with 32 degrees of freedom is attached to $t = 2.73$. Since the value of t obtained exceeds this, the coefficient of partial regression is significant.

We treat the question of significance of the coefficients of partial regression with respect to temperature and concentration similarly. For temperature,

$V_T = 12(-20)^2 + 12(20)^2 = 9600$

Hence:

$$t = \frac{r_T}{\sqrt{\frac{1}{V_T}\frac{\Sigma (D-D')^2}{n-k-1}}}$$

$$= \frac{1.11}{\sqrt{\frac{1}{9600}\frac{1903}{32}}}$$

$= 14.10$ with 32 degrees of freedom

For concentration,

$V_c = 9(-.15)^2 + 9(-.05)^2 + 9(+.05)^2 + 9(+.15)^2 = .45$

Hence:

$$t = \frac{r_c}{\sqrt{\frac{1}{V_c}\frac{\Sigma (D-D')^2}{n-k-1}}}$$

$$= \frac{.112}{\sqrt{\frac{1}{.45}\frac{1903}{32}}}$$

$= 9.74$ with 32 degrees of freedom

Thus, the effect of all three factors on detergency is significant since t exceeds 2.73 in each case.

We have shown that the effect of time on detergency is significant and that the most likely value of the partial coefficient of regression is 1.45 units per minute. We cannot say, of course, that this is exactly the true effect of time on detergency. However, we shall use Table IV to obtain limits within which the true effect is likely to be. With 32 degrees of freedom and a probability level of .01, Table IV gives a value of $t = 2.73$. We reverse the formula for calculating t, and calculate the numerator A with

$$\frac{A}{\sqrt{\frac{1}{V_t}\frac{\Sigma (D-D')^2}{n-k-1}}} = 2.73$$

$$\frac{A}{\sqrt{\frac{1}{600}\frac{1903}{32}}} = 2.73$$

$$A = .86$$

The desired limits are $1.45 \pm A$. These are 2.31 and .59. Hence, we say that the effect of time on detergency is somewhere between .59 units per minute and 2.31 units per minute. In probability language, if the true partial regression coefficient were .59, the chance of getting a regression coefficient as high as 1.45 from our data would be .01; and if the true regression coefficient were 2.31, the chance of getting a regression coefficient as low as 1.45 would be .01. Hence we say that the regression coefficient is very likely to be somewhere between .59 and 2.31. If these limits are sufficiently close together for the engineer's purpose, he has all the information he could want. Otherwise, he must perform additional tests.

In a similar way, we obtain limits for the coefficients of partial regression of detergency with respect to temperature and concentration. For temperature,

$$\frac{A}{\sqrt{\frac{1}{9600}\frac{1903}{32}}} = 2.73$$

$A = .22 \quad 1.11 - A = .89$

$1.11 + A = 1.33$

Hence, the coefficient of partial regression is very likely to be between .89 and 1.33. For concentration,

$$\frac{A}{\sqrt{\frac{1}{.45}\frac{1903}{32}}} = 2.73$$

$A = 31,112 \quad 81,112 + A = 143$

Hence, the coefficient of partial regression is very likely to be between 81 and 143.

(Continued on Page 10)

TABLE IV

Probability of a Deviation Greater than t

Degrees of Freedom	.01	.05	.10	.20	.40	.60	.80
1	63.66	12.71	6.31	3.08	1.38	.73	.33
2	9.93	4.30	2.92	1.89	1.06	.62	.29
3	5.84	3.18	2.35	1.64	.98	.58	.28
4	4.60	2.78	2.13	1.53	.94	.57	.27
5	4.03	2.57	2.02	1.48	.92	.56	.27
6	3.71	2.45	1.94	1.44	.91	.55	.27
7	3.50	2.37	1.90	1.42	.90	.55	.26
8	3.36	2.31	1.86	1.40	.89	.55	.26
9	3.25	2.26	1.83	1.38	.88	.54	.26
10	3.17	2.23	1.81	1.37	.88	.54	.26
12	3.06	2.18	1.78	1.36	.87	.54	.26
14	2.98	2.15	1.76	1.35	.87	.54	.26
16	2.92	2.12	1.75	1.34	.87	.54	.26
18	2.88	2.10	1.73	1.33	.86	.53	.26
20	2.85	2.09	1.73	1.33	.86	.53	.26
22	2.82	2.07	1.72	1.32	.86	.53	.26
24	2.80	2.06	1.71	1.32	.86	.53	.26
26	2.78	2.06	1.71	1.32	.86	.53	.26
28	2.76	2.05	1.70	1.31	.86	.53	.26
30	2.75	2.04	1.70	1.31	.85	.53	.26
35	2.69	2.01	1.69	1.30	.85	.53	.25
40	2.65	1.99	1.68	1.29	.85	.53	.25
45	2.62	1.98	1.67	1.29	.84	.52	.25
50	2.60	1.97	1.66	1.28	.84	.52	.25
∞	2.58	1.96	1.65	1.28	.84	.52	.25

Statistical Quality Control What It Is and What It Does

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The word "control", when used in business, implies a procedure by which Management can accumulate and interpret the facts necessary for determining whether or not business activities are proceeding according to plan. Particularly, control means a method for determining when the activities of business are deviating more than they should from the course laid down by Management. In this sense, for instance, production control provides the tool whereby Management can plan deliveries in advance. It sets up a procedure whereby Management need not be concerned as long as production is moving along smoothly; but if there is any significant desired results, it is automatically called to Management's attention in order that steps can be taken for its correction. Sales control, likewise, calls for a means by which sales can be measured against pre-determined management-set standards. Quality control, by analogy, is a method of measuring the quality of a factory's output against management-set standards that are determined by a consideration of all the factors—the requirements of the Sales Department, the capabilities of the processes, the skill of the workmen, the availability of raw materials, and the engineering design—that will produce a maximum profit for the business organization as a whole.

The word "quality" usually implies a high level of perfection in the finished product. A "quality line" means, in the ordinary sense, a product that has superior consumer appeal. This is not the sense in which the word quality is used here. "Quality" does not imply any particular degree of desirability; it is simply a name attached to a characteristic or combination of characteristics of a manufactured product. When the characteristics are compared with a standard — a standard set by Management for the purpose of obtaining a maximum profit—the quality can be said to be good if it meets the standard, to be poor if it is either better or worse than the standard. As an illustration of this definition, consider the problem that faced a manufacturer of a certain small hard rubber product. This particular rubber item was made by the millions every month, and was used for a purpose that allowed dimensions and surface defects a wide range of variation, but called for a specified hardness. The manufacturer had two alternatives. He could use scrap raw material, allowing a large percentage of the parts to fail, and could sell the product at half price; or he could use new rubber, guaranteeing almost perfect performance as to hardness, and could sell the product at full price. His profit margin in each case was the same. In the first case, according to the accepted meaning of the word quality, the product would be poor; in the second case it would be good. However, according to the meaning of the word as it is used here, both qualities would be good, because both would meet the profit standard set by Management. Which of the two manufacturing methods to follow would have to be determined by Management on the basis of saleability. That is, would it be more economical for purchasers of the product to buy the cheaper products and use more of them, or to buy the more expensive parts and use fewer of them? If, in the first case, a standard of 25% defective were allowed, and the price were 50¢ per thousand, it might pay the purchaser to buy the 25% defective material rather than a practically perfect product that cost $1.00 per thousand. It is problems such as these that make it necessary to define the word quality in a concrete and definite sense as a comparison of objective characteristics of the product with management-set standards for those characteristics. With this meaning, the words **acceptable quality** apply to a product whose objective, measurable characteristics conform to the standard. If the product is either superior or inferior to the standard, it is unacceptable because in the one case it would probably be too expensive to produce, and in the other case it would not meet the purchasers' requirements.

Quality control in the broad sense requires the coordination of consumer research, product research, and production research, with special emphasis on cost, directed towards meeting the standards set by Management. In the operation of quality control three distinct steps are involved. First, accurate, correct and adequate facts should be gathered, and these facts should then be properly analyzed and interpreted. Second, from these facts and the conclusions drawn from them, Management should set the standard of quality for the outgoing product. Third, control procedure should be set up in order to assure management that the operations of the business are being conducted at the desired level, and that any significant deviation therefrom is corrected promptly. Statistical quality control is a method of applying statistical techniques to the collection and analyzing of inspection and other data in order to achieve and maintain maximum economy in manufacturing processes.

(1) This article is an excerpt from the introduction to the author's forthcoming book, **Control Charts in Factory Management** to be published by John Wiley & Sons, New York.

Statistical Techniques

This concept of statistical quality control includes several significant ideas. First of all, it uses statistical techniques. Statistics is the science of collecting, measuring, analyzing, and interpreting quantitative facts. As applied to the quality characteristics of a manufactured product it makes possible the establishment of sound norms or standards, and enables Management to differentiate clearly between deviations which (a) should be expected by chance in the operation, or (b) are too large to occur by chance alone. For instance, a salesman sells $5,500 worth of goods last month but only $3,500 this month; should he be complimented on last month's record, should he be discharged because of this month's record, or should nothing be said? From the two months' data given, it would be impossible to tell. If records of the salesman's monthly sales for several years back were available, it would be possible by statistical techniques to show whether or not this month's sales were smaller than should normally be expected, in view of the variation in his previous record. Similarly, when a machine produces a part that is too large or too small, according to specifications or other standards, it is possible, from an engineering study and statistical analysis of the operation, to determine whether or not that piece was one which the machine could normally be expected to produce. Or suppose that a workman produces 5% bad work today against only 1% yesterday; it may be difficult to tell whether or not he should be reprimanded. If, for instance, during any month his record varies from 0% to 9% bad work, common sense alone would indicate that he should not be blamed for a 5% day. By drawing definite limits between what variation can be expected and what is unexpected, and by comparing these limits with the variations that are determined to be economical by Management, statistical techniques enable Management to take action in the right direction when troubles are found to exist. The control chart, which is the subject of this book, is one of the simplest, most practical, least expensive and most reliable techniques ever devised for helping Management to keep economic control of its processes.

Analysis of Facts

Statistical quality control requires the analysis of facts. In most manufacturing plants the collection of quantitative data about the product is a function of the inspection department. Statistical quality control should, therefore, start with inspection, for the purpose of making sure that the facts collected are adequate and correct. In this respect there are two phases of the statistical quality control function. Firstly, the **routine** accumulation of inspection records should be so organized that the necessary facts can be analyzed quickly and easily. This may involve such changes in the inspection department as an evaluation of the various inspetcors' abilities, the installation of sampling plans, the setting up of process inspection procedures, and the checking of the inspection department's work in order to ascertain whether or not inspection is providing data with the required accuracy and reliability. Secondly, statistical quality control often requires special inspections to be undertaken in special ways in the course of special studies of factory operations. This is a particularly important function of quality control, because it is similar to experimental work in which the design of the experiment, that is, the way in which the data are collected, can be made most efficient by the application of modern statistical techniques to the planning of the experiment. In both routine and special phases of inspection, the purpose is primarily to deduce the nature of a given process from measurements and observations made on the product of that process. In other words, the character of the man is judged by his appearance. This is, in fact, one of the best ways in which the characteristics of a process can be judged. As an illustration, a certain soap manufacturer had his chemists devise a new formula with a supposedly special skin-protecting quality. He tested the first cakes of soap produced by the new formula and found that they actually did possess the properties desired. But if he had not tested the soap he would not have known with certainty whether the soap did have the characteristics he wanted. As another illustration, an open end wrench was designed with certain specifications, among them the requirement that the sides of the jaws should be parallel. It was specified that the openings could be either broached or milled. Neither of these processes, however, produced openings with parallel jaws. The broaching operation caused a toe-in at the points, and the milling operation caused a toe-out at the points. After considering the use for which the wrenches were designed, Management came to the conclusion that neither the toe-in nor the toe-out was large enough to affect the usefulness of the tools; therefore, both operations were permitted. No matter how good the designing is, nor how perfect the planning, the production has to be done by people who are fallible, and by machines that are not perfect. It can, therefore, never be assumed that the product is all that it is desired to be. The only way to find out in what respect and how much the manufactured product deviates from the designed product is by investigation of the physical characteristics of the product. This is the inspection function.

Quality of the Process

When statistical quality control is used in a plant, the first step, as pointed out above, is to make sure that the data collected are adequate and of the right kind. The collection of data is merely a means to an end. The next step is to infer from the characteristics of the product what the characteristics of the process are. Here the real meaning of the word quality as used in statistical quality control becomes clear. The word quality refers much more to the quality of processes than it does to the quality of products. If a process is capable of meeting the specifications set by Management, with the economy necessary for maintaining acceptable costs, then the quality of the process is good. Au automatic screw machine will illustrate this point. If the tolerance on a certain automatic turning is plus or minus .001 inch, and a six spindle automatic can maintain not better than plus or minus .002 inches, then the process is not satisfactory and the quality is not good. In this situation it may be necessary to change the design tolerances, or to use a different process. It is often possible, however, by means of control charts, to reduce the variability in a six spindle automatic to the

region of plus or minus .001 inch. In that case the process will be producing what Management desires, and the quality of the process will be acceptable. On the other hand, suppose that the management-set tolerances are plus or minus .003 inch. If the machine can hold plus or minus .002 inch, then greater efficiency may be achieved by allowing the tools to run a little longer, or by using an older and less accurate machine. The importance of knowing what the operation **does,** what it **can do,** and what it **must do,** if maximum efficiency is to be obtained, is self-evident. The techniques of statistical quality control are well adapted to solving this type of problem, and to giving Management the information it needs for making sound decisions as to the maximum profit potential of its business.

Operating Standards

When inspection data have been analyzed and applied to improving and controlling an operation, Management is in a position to set its standards. Before standards can be set, however, the operation must have become so stabilized that Management can be reasonably sure that the standard will be maintained. This requires that a state of statistical control be established. If control charts have been run on an automatic screw machine and they show that the machine is capable of producing a certain part within limits of plus or minus .001 inch; and if the chart shows that these limits have been held for hours at a time, then Management can confidently predict that future operations will also maintain these limits. Then, Management can safely set a standard for that operation of plus or minus .001 inch, with the knowledge that a minimum of down time will be required. If, however, Management does not know that the operation can maintain plus or minus .001 inch for a long period of time—that is, if frequently parts are made too large or too small, then management cannot confidently set a limit of plus or minus .001 inch because the maintaining of those limits may require an excessive amount of down time. A state of statistical control can also be called a state of "valid predictability," in which the **future** product quality of the operation can be predicted with a high degree of confidence from the product already produced.

When a state of statistical control has been achieved and Management has been able to set economical, valid and reliable standards, the procedure for making sure that the standards are maintained should be set up. This can be done through the techniques of statistical quality control, with less attention by management than would be possible if statistical control were not achieved. Primarily, the same statistical techniques that are used to **achieve** control can also be used for **maintaining** that control.

Profit Control

Quality control can perhaps better be called **profit control.** Economy can be gained by improving the process, or by improving inspection methods, or by changing the design, or by changing the user's idea of what he wants. A few examples will illustrate the type of improvement that can be made in each of these ways.

1. **Improving the process.**

A plant that specializes in automatic screw machine turnings had about 100 screw machines, some new, some old. It was difficult to schedule the work because often the machines were unable to hold the tolerances required. A great deal of blame was laid on the old machines, and it was proposed to buy new ones in their stead. On one particularly difficult job, where the specifications called for a tolerance range of .002 inch, inspection showed that, in a run of 1000 pieces, the difference in size between the largest and smallest piece was .006 inch. This being one of the old machines, it had been decided to replace it with a new one, when statistical quality control was introduced into the plant. One of the first studies undertaken was on this particular operation. Control charts were kept on the machine over a period of about three weeks, at the end of which time many minor maladjustments had been corrected and the operating range of the machine had been reduced to .002 inch. The result was so worthwhile that the same technique was applied to all the other old machines, with similar results. It was then discovered that the old machines were producing work with a smaller range of size than the new machines were. Studies were then conducted on the new machines, and similar improvements were made. On most of the machines it was found that the principal cause of the excessive variation was due to differences between the spindles. When these differences had been removed most of the causes of trouble were eliminated. The control chart technique, applied in this case, made it unnecessary for the company to invest large sums of money in new equipment; in fact, with their old equipment they were doing closer work than most of their competitors who had new machines.

The people who work at machines are certainly a part of the process. Control charts have often brought about improvements in the quality of work, where hand work is the major factor. In a certain plant there were about 30 men working in the Polish Department. Two of these men, Mr. A and Mr. B, vied with each other week after week for the worst quality record. When statistical quality control procedures were applied in the Polish Department, the daily records of inspection were plotted on control charts, one chart for each workman. Mr. A and Mr. B both averaged about 9% defective work. After sufficient time had elapsed for the charts to tell the story, the department head called these two men into his office to show them the charts. After this discussion, Mr. A showed an improvement overnight from an average of 9% bad work down to 2%; Mr. B showed practically no improvement. Shortly thereafter both men were working side by side for two days on the same job. Mr. A averaged about 2½% bad work, Mr. B about 12%. The latter, who had a violent temper, flew into a rage when accused of not doing good work. He insisted that his work was just as good as Mr. A's. When Mr. B was taken out to the polish wheel and asked whether a certain piece was up to standard, he said it was. The department head insisted that any good polisher would know that it was not up to standard. When the argument was over, Mr. B was advised to go to an oculist. There he discovered that his eyesight was poor, and that the reason he was doing bad work was that he could not tell the good work from the

bad. A pair of glasses solved his problem and enabled him to keep pace with his competitor, Mr. A.

2. **Improving inspection.**

In almost every plant statistical quality control can bring improvements and economies in inspection that could not be achieved in any other way. Often products are inspected one-hundred per cent that need only to be sampled; sometimes sampling is done on characteristics that should be one-hundred per cent inspected. Sometimes the qualities that need real inspection are not even realized. A case of this sort arose in the assembly of a ball and spring into a hole that was drilled in a metal bar. The assembly process consisted of dropping the spring into the hole and of crimping the ball in on top of it. Trouble was being encountered because often the ball heights would run from 25% to 50% higher than the tolerances allowed. A detailed and lengthy statistical analysis of the product was undertaken, including a study of the variability in the crimping process and correlation analysis of the height of the balls with the depth and diameter of the holes into which they were crimped. As a result of this investigation it was discovered that the diameter of the hole was the controlling factor in the variability of ball height; the larger the hole, the higher the ball; the smaller the hole, the lower the ball. As a result of this finding, and in order to control the diameter of the holes as economically as possible, a scientific process sampling procedure was set up by which the operator could be sure that the holes were maintained to tolerances with a minimum of time spent in gauging. Thereafter, practically no high balls appeared in the finished product.

In another case, a problem arose in connection with the straightening of metal bars. These bars were made in various sizes, some very large and some very small. It was general practice to straighten the large ones after annealing, when they were soft, and then to one-hundred per cent inspect them after heat treatment and other operations, in order to pick out those that had been made crooked subsequent to annealing. With the small bars, however, it was general practice to send them straight through to heat treatment and final inspection and to straighten only those that were too crooked to meet the standard; these had to be straightened hard, which was a much more difficult and costly process. A high percentage of crooked bars had been found at final inspection for many months. The problem arose, when should the bars be straightened soft, and when hard? A study was made, for each size of bar, of the unit cost of straightening when soft and straightening when hard. A simple straightness gauge was also designed. With the cost data at hand, and with the new gauge which provided an objective, quantitative measure of straightness, it was possible to determine for each size of bar what percentage could most economically be allowed to pass on to final inspection without being straightened when soft. In order to make sure that the straighteners did not undertake to straighten when it was not necessary, and to prevent them from passing lots that did need straightening, a sample inspection was made on every lot just prior to the straightening operation. When the sample inspection showed that the percentage of crooked pieces was larger than the economical percentage allowed, that lot was sent in to the straighteners to be straightened when soft; otherwise, the lot was passed on to final inspection, and the crooked pieces were rejected there and sent back for straightening. During this study, control charts were kept on each of the straighteners and on the straightening press. Among other things, it was discovered that the press needed a complete overhaul; and that one of the straighteners — the one who had been employed longest — was doing an inferior grade of work. When these faults were corrected, the cost of straightening was reduced by almost fifty per cent.

3. **Improving the design.**

It is often difficult to decrease the variability or "scatter" in a manufacturing process. The newly employed manager of an aircraft parts plant realized the truth of this statement shortly after he had assumed his new responsibilities. He discovered that far too large a proportion of production cost was being charged to reworking and repairing parts that had failed to pass inspection. A statistical investigation revealed process variations up to five times the tolerance ranges specified on the blue prints. An investigation of engineering designs naturally followed these findings. In the case of a shaft and bearing assembly, the shaft had an engineering tolerance range of .0005 inch, and the bearing a tolerance range of .0008 inch. Analysis of the manufacturing process showed that so far as production was concerned, the reverse situation was true: the operating tolerance range on the shaft was .0007 inch and on the bearing .0004 inch. Because the design and production tolerances did not agree, rework costs had been excessive. Since in this case it was easier to change the blue-prints than to change the process, the specifications were simply reversed. No harm was done to the assembly — minimum and maximum clearances between shaft and bearing were still the same — practically all rework on account of the shaft failing to gauge was eliminated. The table below illustrates how this problem was solved to the benefit of all concerned.

Before Correction

	Engineering Tol. Range	Operating Tol. Range
Shaft	.0005"	.0007"
Bearing	.0008"	.0004"

After Correction

Shaft	.0008"	.0007"
Bearing	.0005"	.0004"

Before the correction was made the shaft-manufacturing process had overflowed its specifications by .0002 inch, while the bearing process had too much by .0004 inch. After correction both were inside their tolerances.

It is sometimes possible to open up engineering tolerances with benefit to all and harm to none. One instance of this sort occurred in connection with the assembly of a metal bar into a block. The square hole in the block was hot punched, but the square that fitted the hole on the end of the bar was upset. The tolerance on both operations was plus or minus .002 inch. The inspection performed at the upsetting process resulted in frequent stoppages of the job be-

cause of parts failing to gauge. These stoppages became so frequent as seriously to hinder the work of that department. A comparative analysis of the inspection records at the upsetting and assembly operations revealed that no failures in assembly were discovered. The discrepancy in these two inspection records indicated that, in all probability, the specifications on the upset end were too tight. A statistical analysis of the hot punched holes and of the upset squares showed that, if the square were upset to an average .005 inch smaller than the average size of the hole, the assembly could be made with complete satisfaction, while allowing a tolerance range on the upsetting operation of .008 of an inch. The Engineering Department, upon being shown these findings, agreed to an experimental relaxation of the upsetting tolerance range from .004 to .008 of an inch. After a week's trial had shown no defective assemblies, the Engineering Department agreed to make the new upsetting tolerances permanent.

4. Changing the user's idea

An excellent illustration of this type of improvement is given by Sir Charles Darwin, Director of the British National Physical Laboratory. In a paper he presented to a joint meeting of the Institution of Physical, Mechanical, and Electrical engineers, and published in **Nature** on May 23, 1942, he gives an example taken from the manufacture of time fuses for anti-aircraft guns. He says, "Suppose that the lethal area of a bursting shell is such that, if it explodes within a tenth of a second of the set time, it will make a kill. The gunner, therefore, demands of the manufacturer that he make a fuse with an accuracy of one-tenth of a second. The manufacturer works out his method, but finds, whereas it is easy to get a fuse accurate to one-fifth of a second, he will have a lot of trouble to get one with an accuracy of one-tenth; and indeed, he estimates that for the same effort and cost he could not hope to get more than a quarter as many fuses with an accuracy of one-tenth of a second as he could fuses with an accuracy of a quarter of a second. Then, half his shells will burst within the range asked for, and so, in fact, he would be wise to accept an inferior fuse, since he would thereby get four times as many shells, of which half would do what he wanted, and he would, therefore, double the rate of killing. I need not say that I have over-simplified the business; on one side I have left out the cost of the other parts of the shells, and on the other, I have forgotten that the gunner has uncertainties of range to consider, so that his demand for a tenth of a second is more exact than he can justify for practical use.

"My example is intended to show that it is good business for the user and the maker of any article to get together before deciding the tolerances of manufacture. The user may be inclined at first to feel that in doing this he is surrendering some of his freedom of choice, but if you will consider it closely you will see that this is not so. He does not have any real freedom of choice, since he must surely try to design the article so as to be as easy to make as possible. I may summarize this aspect of the matter by saying that the user has in the past tended to demand that everything should be made for him as well as possible; but he ought to want everything made for him as badly as possible, or perhaps not quite that, but as badly as permissible. It is in this aspect that statistical quality control especially gives the right information."

The user of a product should certainly not pay for any better quality than he needs. Closer tolerances, finer finish, better fit, more durability — all these, if they exceed what is economical from the purchaser's standpoint, make the product he buys more costly to him than it should be. Sometimes, as Darwin points out, the buyer of a product actually does not know what he should have. Sometimes the manufacturer, by means of education and discussion, can show the purchaser that the thing that is most economical for him (the manufacturer) is also economical for the user. If this cannot be done, it is certainly true that the manufacturer, by getting the desires of the purchaser or user in concrete, definite form, gains highly valuable information for use in setting his own standards. In any case, the manufacturer has nothing to lose and much to gain by the type of consumer research that will enable him to produce his product intelligently and economically.

Consumer research is usually undertaken by the Sales Department. Consequently, the Sales Department should have a primary place in any full-scale quality control program. In the literature of quality control up to the present time, there has been too little discussion of the Sales Department's role. Unless the factory knows, not only from the engineering, but also from the consumer standpoint, what objective quality characteristics its product should have, it cannot make production decisions with an eye to maximum efficiency; and unless the inspection department also knows the why and wherefore of quality standards, it cannot perform its function intelligently. Viewed in this light, the quality control department can make its work the cornerstone of company planning. It can become the co-ordinator of sales, production and inspection, in the area where they infringe upon each other — the setting and maintaining of Management policy regarding product and process quality.

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(Continued from Page 5)

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Society Of Quality Control Engineers In Michigan

Extensive Program Planned For 1946

Plans for an extensive program in 1946 were mapped out by W. S. Oliver, chairman of the Detroit Quality Control Society.

Plans include an enlarged program throughout the state with sub-groups located at strategic points. These groups would be in close touch with the parent organization in Detroit, and it is hoped in this way to simplify the transportation problem. Speakers will visit these sub-groups as well as the main group in Detroit. The first of these meetings is expected to be held in Battle Creek during the month of February.

Other plans include a bi-monthly copy of INDUSTRIAL QUALITY CONTROL to each member, thereby helping them keep in touch with modern developments in the field. Speakers also are expected to be brought in periodically, and inter-group discussions are expected to keep up the at-home interests.

Dates for meetings were set as follows: January 31, March 14, May 2, June 13, August 1, September 12, October 24, December 12, and January 10, 1947. All of these meetings will be held in the Rackham Memorial Building in Detroit. More details will be announced later.

Report of Annual Meeting

The Detroit Quality Control Engineers enjoyed their annual dinner meeting at the Old Wayne Club in Detroit on the evening of December 14. This meeting, as is the custom, was a combined business and social meeting open not only to the "Society" members but wives and sweethearts as well.

The meeting furnished an ideal opportunity to forget the headaches of the times, and substitute for them pleasure, contentment, and friendship, both old and new. The committee in charge arranged a fine meal and entertainment. Numerous piano selections were offered and Tommy Evans, favorite Detroit tenor, sang several popular solos and led in singing by the group.

Professor C. C. Craig, of the University of Michigan, enlightened the group on the history of Quality Control, its status at present, and its prospects for the future.

Results of the society's election were then given and found Walter S. Oliver of the United States Army Ordnance elected to the office of chairman; Russell C. Trombly of the Hoover Ball & Bearing Company, vice chairman; I. E. R. Benson of Cadillac Motors, secretary; Joseph Gurski of Ford Motors, treasurer; and Clarence Kooistra of Hoover Ball & Bearing Company, and Robert Lainc of Reo Motor Car Company as Boa d Members. A feature of this ye r's election was that it was carried out by mail, thereby giving all members a perfect opportunity to express their choices even though unable to attend this meeting.

Detroit Progress New Course in Basic Quality Control

The University of Michigan has announced a new condensed course for beginners in Quality Control. This course will cover approximately the same material as was covered in the now well-known "Eight-day Course" although it is hoped to go beyond this scope in some respects. The course is sponsored by the Extension Division of the University of Michigan and classes will meet weekly on Wednesday evenings in the Rackham Memorial Building in Detroit. Classes will start on March the 6th and will run for sixteen weeks. Fees for the course are expected to be approximately $15.00. A first course in college mathematics will be a prerequisite for the course. It is hoped in doing this to be able to speed up progress in the classroom. Professor C. C. Craig of the University will be in charge.

The University of Michigan at the present time is also offering, on the campus, an enlarged course in Quality Control. This course offers three hours of credit and is attracting interest especially in the Department of Engineering. This enlarged course has a prerequisite of one year of calculus.

NOTICE TO SUBSCRIBERS

Each time INDUSTRIAL QUALITY CONTROL is published several copies are returned by the post office marked undelivered. As you know third class mail cannot be forwarded. Therefore we would appreciate your cooperation in providing your new address when you make a change of residence or business connection, if we are using your business address. We have taken your money and are anxious to perform our part of the contract by supplying copies of the magazine. But we cannot do so unless you keep us informed of your address.

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Chicago 49, Illinois

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Tuesday and Wednesday
March 5 and 6, 1946

LaSalle Hotel
Chicago, Illinois

PROGRAM

TUESDAY, MARCH 5

9:00 A. M. — Registration — Mezzanine

9:30 A. M. — Morning General Session

Illinois Room — Mezzanine
Presiding: Warren E. Jones,
General Chairman,
Midwest Quality Control Conference

WELCOME

Leverett S. Lyon,
Chief Executive Officer,
The Chicago Association Of Commerce

SUBJECT: "A Complete Quality Control Program"

Speaker: Joseph G. Manuele,
Director Of Quality Control,
Westinghouse Electric Corporation,
East Pittsburgh, Pa.

SUBJECT: "Industrial Statistics Looks At The Future"

Speaker: Paul Peach,
Institute Of Statistics,
North Carolina State College,
Raleigh, N. C.

12:15 P. M. — Luncheon

Reconversion Problems School — Grand Ballroom

The Chicago Association Of Commerce

Guenther Baumgart, Manager

SUBJECT: "Quality Control — A Management Tool"

Speaker: M. Herbert Eisenhart, Pres.
Bausch and Lomb Optical Co.,
Rochester, N. Y.

2:00 P. M. — Afternoon General Session

Illinois Room — Mezzanine
Presiding: Warren E. Jones

SUBJECT: "The Relation Of The Quality Function To The Industrial Enterprise."

Speaker: J. M. Juran,
Department Of Administrative Engineering,
New York University,
University Heights, N. Y.

SUBJECT: "Foundry Applications Of Quality Control"

Speaker: A. E. R. Westman, Director,
Ontario Research Foundation,
Toronto, Ontario, Canada

4:15 P. M. — 5:45 P. M. Recess Exhibits

5:45 P. M. — 6:30 P. M. Cocktail Hour — Century Room — 19th Floor

6:30 P. M. — Banquet

Grand Ballroom — 19th. Floor
Presiding: Warren E. Jones

Toastmaster: Martin A. Brumbaugh,
School Of Business Administration,
University of Buffalo,
Buffalo, N. Y.

SUBJECT: "The Future Of Quality Control"

Speaker: George D. Edwards,
Director Of Quality Assurance
Bell Telephone Laboratories,
New York City, N. Y.

Entertainment: Motorola Glee Club
Galvin Manufacturing Corporation,
Chicago, Illinois
Bob Lotz — "Sophisticated Magic"

WEDNESDAY, MARCH 6

9:00 A. M. CLINICS

1. SUBJECT: "Some Principles Of Quality Control by Statistical Methods"

Chairman: Lloyd A. Knowler, Department Of Mathematics, State University of Iowa, Iowa City, Iowa

2. SUBJECT: "An Application Of P-Charts"

Chairman: Keith E. Ross, Product Quality Division, General Electric Company, Fort Wayne, Ind.

3. SUBJECT: "The Quality Control Organization"

Chairman: Alfred L. Davis, Rochester Institute of Technology, Rochester, N. Y.

4. SUBJECT: "Some Quality Control Methods For Short Runs and Job Shop Lots"

Chairman: Ralph E. Wareham, Manager, New Products, National Photocolor Corporation, New York City, N. Y.

5. SUBJECT: "Practical Application Of Quality Control At The John Deere Tractor Company"

Chairman: E. L. Fay, Chief Inspector, Deere and Company, Waterloo, Iowa

10:15 A. M. CLINICS

6. SUBJECT: "Demonstration And Construction Of Averages And Range Charts"

Chairman: Lloyd A. Knowler, Department Of Mathematics, State University Of Iowa, Iowa City, Iowa

7. SUBJECT: "The Use Of Statistics In The Design Of Experiments"

Chairman: Paul Peach, Institute Of Statistics, North Carolina State College, Raleigh, N. C.

8. SUBJECT: "How Quality Control Is Introduced To Top Management"

Chairman: Fred J. Halton, Jr., Assistant To President, Deere and Company, Chicago, Illinois

9. SUBJECT: "Some Methods For Selecting and Training Personnel In Statistical Quality Control"

Chairman: Edward D. Thompson, Chief Inspector, Fansteel Metallurgical Corp., North Chicago, Illinois

10. SUBJECT: "Quality Control By Statistical Methods Applied To Straight Line Production"

Chairman: E. F. Gibian, Chief Industrial Engineer, Thompson Aircraft Products Co., Cleveland, Ohio.

11:15 A. M. — 12:15 P. M. Recess — Exhibits

12:15 P. M. — Luncheon

Grand Ballroom — 19th. Floor
Presiding: Warren E. Jones

SUBJECT: "Reporting Quality Results to Management"

Speaker: Martin A. Brumbaugh, School Of Business Administration, University of Buffalo, Buffalo, N. Y.

2:15 P. M. CLINICS

11. SUBJECT: "Application Of Averages and Range Charts"

Chairman: Lloyd A. Knowler, Department Of Mathematics, State University Of Iowa, Iowa City, Iowa

12. SUBJECT: "The Application Of Statistical Methods To The Inspection Of Porcelain Enamel"

Chairman: Lester S. Kauffman, Quality Control Director, American Stove Company, St. Louis, Mo.

13. SUBJECT: "Quality Control As Applied To The Mass Production Of Precision Ball Bearings"

Chairman: C. R. Scott, Jr., General Supervisor Of Quality, SKF Industries, Inc., Philadelphia, Pa.

14. SUBJECT: "Special Techniques IN P-Charting"

Chairman: Herbert J. Sprengel, Quality Control Engineer, General Electric Corporation, Chicago, Illinois

15. SUBJECT: "Quality Control In Processes Involving The Human Element"

Chairman: James M. Ballowe, Manager, Quality Inspection Division Department, Aldens, Chicago, Illinois

3:30 P. M. CLINICS

16. SUBJECT: "Introduction To Fraction Defective Charts"

Chairman: Lloyd A. Knowler, State University Of Iowa, Iowa City, Iowa

17. SUBJECT: "Sampling Of Incoming Material"

Chairman: Lt. J. L. Shafer, (jg) USNR Inspector Of Naval Material Chicago, Illinois

18. SUBJECT: "Quality Control Farmall Training Course"

Chairman: J. E. Rahn, Jr., Special Engineer For Quality Control, Farmall Works, International Harvester Co., Rock Island, Illinois

19. SUBJECT: "Statistical Quality Control In Radio Manufacture"

Chairman: Fred Trowbridge, Quality Control Engineer, Sentinel Radio Corporation, Evanston, Illinois

20. SUBJECT: "Quality Reporting — Putting Inspection Results To Work"

Chairman: Harold R. Kellogg, Engineer, Quality Control, Western Electric Company, Inc., Hawthorne Works, Chicago, Illinois

Quality Control Engineers OF ROCHESTER

SECOND ANNUAL QUALITY CONTROL CLINIC

Tuesday, February 19, 1946
at the
Chamber of Commerce Bldg.
55 St. Paul Street

12:15 p. m. — Luncheon.

Speaker: Myron J. Hayes, Vice-President and General Manager of the Camera Works and Hawk-Eye Works, Eastman Kodak Company.

SUBJECT: "What Does Management Expect from Quality Control."
Presiding: Halsey H. Kent, Vice-President, Quality Control Engineers of Rochester.

2:00 p. m.-4:30 p. m. — Quality Control Clinics.

4:30 p. m.-6:00 p. m. — Recess — Gage Exhibits.

6:15 p. m. — Dinner.

Greeting and Comment: Chairman of the Industrial Management Council.
Speaker: Andrew I. Peterson, Director of Research, Victor Division, Radio Corporation of America, Harrison, N. J.

SUBJECT: "Critical Needs in the Quality Control Profession."
Presiding: Alfred L. Davis, President, Quality Control Engineers of Rochester.

CLINICS

1. SUBJECT: "The Technique of Installing a Quality Control System"
Chairman: Martin A. Brumbaugh, Professor, School of Business Administration, University of Buffalo, Buffalo, N. Y.
Clinic designed to meet the needs of those wishing to introduce for the first time the principles of Quality Control into an industrial situation.

2. SUBJECT: "Measurement Charts for Tool Wear"
Chairman: Paul Peach, Industrial Statistician, North Carolina State College, Raleigh, N. C.
This clinic will appeal to those already engaged in Quality Control. A specific use of control charts will be introduced and suggestions made as to application of charts where tool wear is a major factor in the production process.

3. SUBJECT: "Keeping Up To Date in the Gaging Field"
Chairman: Ralph Lilleberg, Gage Sales Manager, The Sheffield Company, Dayton, Ohio
The most recent developments in gaging practice and technique will be discussed. Additional emphasis will be placed on the role which gages can play in obtaining better control of production.

4. SUBJECT: "Quality Control in the Chemical Industry"
Chairman: Charles A. Bicking, Engineering Department, Hercules Powder Company, Wilmington, Del.
This clinic will be devoted to applications of Quality Control principles to problems arising in the chemical industry. Specific suggestions will be made as to applications in controlling chemical processes.

5. SUBJECT: "Controlling Quality of Sub-Assemblies"
Chairman: Alfred J. Winterhalter, Quality Manager, Colonial Radio Corporation, Buffalo, N. Y.
A relatively new field of application for Quality Control principles. Specific examples will be given of methods used in controlling quality at this stage of assembly.

6. SUBJECT: "Increasing Your Effectiveness Through the Use of Forms"
Chairman: Richard Eisenhart, Divisional Chief Inspector, Bausch & Lomb Optical Company, Rochester, N. Y.
The forms used in four different industries will be exhibited. Representatives of these firms will discuss the forms presented, their purpose and the values obtained through their use.

7. SUBJECT: "How to Introduce Quality Control to Top Management"
Chairman: Frederick J. Halton, Assistant to the President, Deere and Company, Chicago, Ill.
This clinic will deal with specific ways in which Quality Control can be presented to Management, to insure their interest and support. Suggestions will be made concerning methods of reporting quality performance to Management.

8. SUBJECT: "Quality Control Applied to Job Shop Production"
Chairman: Ralph E. Wareham, Manager, New Products, National Photocolor Corporation, New York City, formerly Director of Quality Control, General Electric Company.
This clinic will deal specifically with the problems related to small quantity manufacture.

9. SUBJECT: "Sequential Analysis"
Chairman: A. R. Jackson, Quality Control Manager, Curtiss-Wright Corporation, Columbus, Ohio.
The merits of existing sampling plans will be discussed with their applications. Special emphasis will be given to the newly developed sequential plan and the values which can accrue through its use.

10. SUBJECT: "Controlling Surface Quality"
Chairman: M. P. O'Dell, Manager, Instrument Department,
Brush Development Company, Cleveland, Ohio.
This clinic will cover the new developments in techniques used for measuring and controlling surface roughness. Suggestions will be made concerning means of establishing standards for surface quality.
11. SUBJECT: "Quality Control in the Receiving Area"
Chairman: Edward F. Guilford, Chief Inspector,
Easy Washing Machine Company, Syracuse, N. Y.
This clinic will point up the relationships which exist between the Purchasing Department and the Quality Control Department. Methods of recording and reporting inspection data will be discussed. Emphasis will also be placed on the subject of establishing a vendor's quality level.

MEETINGS

QUALITY CONTROL ENGINEERS OF ROCHESTER

The November meeting of the Quality Control Engineers of Rochester met at the Chamber of Commerce on November 20, 1945, with Louis E. Young, Quality Control Division, Westinghouse Electric Corp., Springfield, Massachusetts as speaker. His subject was, "Charts to Allocate Responsibility for Quality," and a very interesting meeting resulted. His charts were very complete and ably demonstrated the value of being able to fix the responsibility of quality where it belonged. The meeting was attended by two hundred and six members and guests.

The December meeting of the Quality Control Engineers of Rochester was held at the Chamber of Commerce on December 17, 1945. There were one hundred and seventy members and guests present. The meeting was addressed by W. A. Bennett, Work's Manager, English Needle and Fishing Tackle Co., Studley, Warwickshire, England and M. Milbourn, Physicist, Imperial Chemical Industries, Metals Division, Birmingham, England. This proved to be a very interesting meeting as Mr. Bennett and Mr. Milbourn not only brought us up to date on quality control as practiced in British Industry but gave a very interesting account of industries' experiences during the blitz of England.

The sampling sub control group met at the Chamber of Commerce on December 12, 1945 with an attendance of forty-five. Three speakers representing Stromberg Carlson, Hawk-Eye Works-Eastman Kodak Company and Bausch and Lomb Optical Company presented some interesting data on how to set up a process average for sampling control. This group will meet every other month to discuss further developments in the field of Quality Control by sampling methods.

NOTES ON NOVEMBER MEETING
WM. L. MYERS

Captain E. C. Polidor, chief of the gage section, Rochester Ordnance District, was the speaker at the November 9 meeting of the Gage Control Group of the Quality Control Engineers of Rochester.

He expected to be discharged within a few weeks so gave us a review of his experience while assigned to the gage section of the Rochester Ordnance District. He spoke on all phases of gaging, multi-check gages, bore, and thread gages. He spoke in particular of roll thread snap gages which he recommended. He explained their technique of producing a mold from thread ring gages so as to inspect the thread section. Another thing he emphasized was that a gage received care in proportion to its finish. The gage with the best all around appearance received the most careful use. He also mentioned that units of gages and measuring equipment needed to set up gage control units had been given to the University of Rochester, Syracuse University, and Cornell University from the Rochester Ordnance District and that they were intended for the use of the industries of their surrounding areas. He closed his talk with an offer of cooperation whenever possible between the Rochester Ordnance District and the industries located therein.

We cannot pass up an opportunity to compliment the Walz & Krenzer Social Club who was our host at its Recreation Building, 31 Riverview Place. Mr. Cy T. Krenzer of Walz & Krenzer prepared a dinner beyond reproach and he must be complimented on his ability as both a chef and host.

PURDUE COURSE

An intensive ten-day course, "Quality Control by Statistical Methods," will be given at Purdue University, February 19 to March 1, Prof. Irving Burr announced today. The course is designed to train quality control supervisors, managers, industrial engineers, production engineers, design engineers, and persons in charge of specifications for material how to apply modern scientific methods to inspection in order to control the quality of any product.

The course will be similar to those given at a number of universities under the auspices of the Office of Production Research and Development of the War Production Board, except that the Purdue course will devote more time to sequential analysis and will include correlation.

Major topics for discussion by outstanding leaders in this field include: Statistical Tools and Concepts, Frequency Table Averages and Variability, Control Charts for Measurements, Fraction Defective, and Number of Defects, Acceptance Sampling for both Measurements and Fraction Defective, and Correlation.

The teaching staff will include Edward M. Schrock, of the Aberdeen, Maryland Proving Ground; Cecil C. Craig, of the University of Michigan at Ann Arbor; Mason E. Westcott, Northwestern University, Evanston, Ill.; and Professor Burr. Special lectures will be given by Edwin G. Olds, Carnegie Institute of Technology, Pittsburgh; Carl G. Schmid, Naval Ordnance Plant, Indianapolis, and A. J. Jackson, Curtiss-Wright Corporation, Columbus, O.

A one-day executives' conference will be held Tuesday, February 19, to acquaint top management with the aims and possibilities of a quality control program and to outline the procedure for the installation of such a program in their plants. The remainder of the course emphasizing practical applications of statistical quality control will be made up of daily class work, including lectures and laboratory sessions, with informal group meetings in the evenings.

Inquiries should be directed to the Technical Extension Division, Purdue University, Lafayette, Indiana.

SOCIETY REPORTS

Indiana Society for Statistical Quality Control

The following is a report of the meeting held December 11 at Indianapolis.

The morning session was opened with a short business meeting, after which George West of P. R. Mallory Company explained his company's experience in installing control charts on automatics. Limits set in from the specification limits according to Sealy's "M" factors were used. Five pieces were measured each half hour and averages and ranges were recorded. One operator tends four machines and one inspector carries on the control procedure for five machines. Less essential dimensions which are not charted are inspected 100% before the parts are stored in the crib.

At the afternoon session W. J. Schmeisser of Belden Manufacturing Company reported the savings resulting from control of thickness of copper cable through weighing small samples. W. A. Shideler of Stewart Warner reported the results of training management in control technique before introducing the technique in production areas. Dr. Irving Burr of Purdue University continued his explanation of the use of correlation methods in industry.

Ohio Quality Control Society

The Society met January 11 at Case School of Applied Science to hear Ralph E. Wareham on "Some Quality Control Methods for Short Runs and Job Shop Lots." The control problem of short runs differs from that of the continuous production shop. The ordinary process control procedure should be shifted to equipment control and devices should be installed which will give quick determination of quality and simultaneously will warn speedily of loss of quality level. In most cases of short runs, patrol inspection is preferable to control charts. An exception to this is the case of a product which is made repeatedly, but at intervals. A control chart of previous runs can be used to guide in setting up the current run.

Newark Society for Statistical Quality Control

The Regional Conference held at Princeton University, December 5, was attended by 100 members of the four constituent Societies and about 50 visitors and guests. It is safe to say that everyone who attended would wish to have such regional meetings made a permanent part of the Societies' programs.

Dr. Walter A. Shewhart spoke at the January 30 meeting on "The Future of Quality Control." Dr. Paul Olmstead reported on the Present Status of the National Quality Control Society.

We would call to your attention the next meeting on March 14, on "Quality Control in Penicillin." Here is a field which offers the greatest challenge to the quality control man which we have encountered to date.

Delaware Quality Control Society

The January 7 meeting of the Society was devoted to the subject "Comparing Two Groups of Data." A panel discussion led by Dr. E. V. Lewis with the assistance of John R. Vincent and R. H. Walsh, centered around the question of what changes in a production record are significant, i.e. when shall a process be said to be producing at a new level? The use of statistical technique to show when a significant difference had occurred proved most instructive when applied to records provided by members.

The Society for Quality Control, Northeastern Indiana

This Society was founded as an outgrowth of several classes in Statistical Methods, instructed by Mr. Keith E. Ross, and sponsored by Purdue University. A desire for further knowledge and application of this work was expressed by a number of the men in the classes. As a result of this interest, a Society was founded on December 5, 1945, after several informal gatherings. Twenty-five men, representatives of seven major industries in Ft. Wayne, Indiana, were present at the organization meeting.

The following officers were elected:

President, E. K. Hoppe,
General Electric Company
Vice President, D. H. Mills,
Magnavox Company
Secretary, H. B. Reynolds,
General Electric Company
Treasurer, Robert Harper,
Farnsworth Radio & Television
Counselor, Clay Orchard,
Salisbury Axle
Counselor, R. D. Long,
International Harvester Company
Tech. Advisor, Keith E. Ross,
General Electric Company
Publicity Director, E. J. Cade,
General Electric Company

Society of Quality Control Engineers of California

The following program was presented at the December 6 dinner meeting in Los Angeles.

Mr. V. D. Penland spoke on "Industrial Relation Factors." He showed how certain statistical technics could be applied to measure supervisor performance in terms of absenteeism, requests for transfer, grievances, accidents, quality and quantity of output, tardiness, etc. Mr. Penland showed how 50 reports to executives could be equaled with a few charts thereby increasing the objectivity and assimilation of data. It also provides a means of prediction.

Mr. E. H. Bauer spoke on "Budget Control." He briefly explained the Lockheed Quality stamp system and the means it provides for gathering data. At first Mr. Bauer used p charts but found the limits to be too narrow for large sample sizes. He is now using a chart employing a shifting range. Mr. Bauer had some very interesting charts showing the relationship between inspection load and factory load. He also had some tables showing comparative ratings for various supervisors.

Mr. Ralph A. Wood reviewed recent trends in quality control literature. In brief, Mr. Wood forsees danger in the testimonial type of quality control articles. He suggests that we get back to fundamental publications in the field of Quality Control. Just as lawyers adhere to Blackstone or doctors adhere to

Gray's Anatomy, so should the quality control engineer adhere to Dr. Shewhart's "Economic Control of Quality of Manufactured Product."

The Society of Quality Control Engineers of California is following the policy of publishing several monographs by its members during the year. The first of these is one by Mr. John M. Howell entitled "Statistical Quality Control — Some American Views on its Fundamental Concepts."

Mr. William B. Rice was elected to serve as president of our group for the ensuing year and Dr. Hammer is vice-president, serving as program chairman.

Chicago Society for Quality Control

The Chicago Society for Quality Control held its January 9 meeting in the 42nd floor studio of the Civic Opera Building. Mr. Ralph Wareham, who is very well known in the field of quality control, discussed "Some Quality Control Methods for Short Runs and Job Shop Lots."

At the December meeting, Mr. Frank Palumbo of Galvin Manufacturing Company discussed "Applying Quality Control to Handy Talkies and Walky Talkies."

Philadelphia Quality Control Society

The program committee has arranged a well balanced and instructive series of lectures for our current season. The attendance at each meeting has been very satisfactory in number and even more so in view of the active interest shown by those present and the accompanying membership expansion.

The program for the balance of the season is shown below. We welcome all who wish to attend our meetings held in Conwell Hall, Temple University.

Jan. 18 Quality Control as Applied to Screw Machine Parts, W. R. Reeves, Part Fabrication Inspection and Testing, Victor Division of RCA, Camden, New Jersey.

Feb. 15. Standardization of Performance, W. Edwards Deming, Adviser in Sampling, Bureau of the Budget, Washington, D. C.

Mar. 15. Application of Statistcs to Variables in Woolen Production, John Hintermaier, Supervisor of Cloth Control, Forstmann Woolen Company, Passaic, New Jersey.

Apr. 12 Run Theory Applied to Quality Control Problems, Frederick Mosteller, Mathematics Department, Princeton University Princeton, New Jersey.

May 17 Application of the Control Chart Method to the Control of Quality, John A. Jones, Division Superintendent of Quality Control, Westinghouse Electric Corporation, Lester, Pennsylvania.

Syracuse Society for Industrial Quality Control

Help! Help!

Bio-Chemical Industry in the Syracuse Area is in need of information on Quality Control. It would be appreciated if anyone knowing of data involving quality control of chemical reactions, distillation or allied processes would forward the information on the papers to Mr. J. B. Schrader (Secretary, Syracuse Society) Halcomb Works, Crucible Steel Company of America, Syracuse, New York.

The Syracuse Society is planning a series of plant visits to give any possible help in methods of applying Quality Control. The first will be a dinner and tour of a new plant in Syracuse.

Mr. R. C. Coolbaugh, President of the Syracuse Society, recently gave a talk before the annual State Convention of the Purchasing Agents Association, held in Syracuse. His talk, "Commodity Evaluation by Quality Control Methods" was well received.

A dinner meeting was held January 29 at Hotel Syracuse. Alfred J. Winterhalter, Quality Manager, Colonial Radio Corporation, presented his experiences in "Establishing a Quality Control Department." He emphasized the absolute necessity of securing cooperation at both the operating and management levels, and illustrated with actual cases the need for stressing the cost reduction phase of record keeping when dealing with top management.

Iowa Society for Quality Control

At the September 14-15 meeting the Society for Quality Control —State University of Iowa Group was formally organized. Officers elected were: President, Mr. E. L. Fay, Chief Inspector, John Deere Tractor Company; Vice President, Mr. J. M. Ballowe, Manager of Inspection, Aldens Chicago Mail Order Company; Secretary-Treasurer, Mr. A. J. Munson, Cost Yield Control Superintendent, Clinton Company; Directors, Professor Lloyd A. Knowler, Department of Mathematics, University of Iowa; Mr. R. W. Hanna, Assistant Chief Inspector, Barber-Colman Company; Mr. F. J. Halton, Jr., Assistant to President, Deere and Company; Mr. R. C. Miller, Research Engineer, Elgin National Watch Company.

The program chairman for 1946 is Mr. Wayne M. Biklen, Quality Control Engineer, W. A. Shaeffer Pen Company. Meetings are scheduled as follows: January 25-26, in Iowa City; March 5-6, in cooperation with Mid-West Quality Control Conference in Chicago; May 24-25; October 4-5; and December 6-7.

The first day of the September meeting was devoted to demonstrations and laboratory exercises of acceptance sampling. The usual defects in 10 per cent sampling methods were observed. Various sampling tables were discussed and sequential analysis was introduced. Mr. R. W. Hanna presented some interesting sequential techniques.

On the second day the subject "Quality Control — Farmall Training Course For Shop Supervisors" was discussed by Mr. J. E. Rahn, Special Engineer for Quality Control, International Harvester Company. A paper was presented by Frank A. Palumbo, Quality Control Engineer, Galvin Manufacturing Corporation, concerning the use of control charts in the manufacture of the Handie-Talkie. Mr. H. J. Sprengel, Quality Control Department, General Electric X-ray Corporation, made a report concerning "Quality Control Applied to X-Ray Tube Manufacture."

Mr. J. M. Ballowe, Quality Inspection Department, Aldens Chicago Mail Order Company, presented the paper "How Will Quality Control Reduce Costs?" at the Production Conference of the American Management Association in Chicago last October. Mr. Ballowe related his experiences and success with Quality Control in the mail order business during the preceding twelve months.

Society Of Quality Control Engineers
OF BUFFALO

SYNOPSIS OF DECEMBER 10, 1945 MEETING

This meeting was divided into two parts. Kenneth Rosengren of the Houdaille Engineering Corporation took the platform for the first part of the session to tell the Society how quality control started at his plant and what was accomplished. The first step taken was a thorough check of the records of the salvage department to obtain an accurate picture of the scrap produced during the past few months. This action confirmed the worst suspicions—the fraction defective of the parts produced was much too high. A further investigation established that only one out of fourteen machines was capable of producing parts of the fraction defective aimed at by the Quality Department. A correction of this condition would require a long term program involving the rebuilding and replacement of machines. However, through cooperation of the foremen and the tool engineers, a quality control program was launched which soon resulted in a reduction of scrap to one-half of its previous level. This action resulted in the savings of approximately $45 a day. Through the information obtained from the periodic measurement of samples of five pieces, the tool setters and tool engineers soon understood how the product varied in a predictable manner. The operators and tool setters learned the value of the proper setup to take full advantage of the tool wear cycle. The information obtained was of great value to the tool engineers in aiding in the design of proper tools. Mr. Rosengren promised to return to the platform at a later date when his quality control program becomes more completely established.

Martin A. Brumbaugh's paper "Tool Wear Charts" presented during the second part of the program developed further many points mentioned by Mr. Rosengren. Dr. Brumbaugh stated the tool wear chart may be used if:

1) The machine is too good for the job.
2) Improvement of the process reduces the range.
3) An assignable cause of variability (tool wear) is retained in the process.

Naturally if the control limits as computed from the data obtained off the machine are outside the specifications limits, even though good control is indicated, there is no room for the tool wear. Scrap is always being produced with the attendant requirement that all pieces be 100% inspected. Likewise, if the control limits and the specification limits coincide, tool wear cannot be tolerated. The entire effort must be expended to keep the machine "on the beam" if scrap is to be avoided. Where the control limits are well inside the specifications limits, there is room for tool wear. To prepare the tool wear charts, the following steps were proposed:

1) Obtain a record of the machine as quickly as possible from measurement of
   (a) 10 or 12 samples taken periodically
   (b) the first 50 pieces produced
2) Compute $\bar{R}$
   (a) If (a) above is used, R is obtained directly from the data
   (b) If (b) above is used, compute σ' and get $\bar{R}$ from the relation $\bar{R} = d_2 \sigma'$.
3) Test $\bar{R}$
   (a) If $\bar{R}$ is not greater than $\frac{d_2}{6}$ (upper specification — lower specification), the process is capable of producing 100% effective parts but there is no room for tool wear.
   (b) If $\bar{R}$ is not greater than $\frac{d_2}{12}$ (upper specification—lower specification), there is room for tool wear.
4) Set the control limits in from the specification limits
   (a) If (a) of 3 applies, use for control limits:
   (Upper specification $- A_2 \bar{R}(\sqrt{n}-1)$
   (Lower specification $+ A_2 \bar{R}(\sqrt{n}-1)$
   (b) If (b) of 3 applies, then set the control limits by coming in 3 σ' from each specification limit.

Report of the Nominating Committee

Amendment I to the Constitution of the Society of Quality Control Engineers provides for the election each year of two members to the Executive Board. Each member is to serve a three year term. The nominating committee submitted the names of the following members:

G. V. Herrold
George Moore
J. K. Polworth
William Wells

A ballot containing the above names together with an addressed stamped envelope was mailed to all members of the Society. The ballots must be returned by February 1, 1946.

January Meeting

The Institute of the Aeronautical Sciences invited members of the Society of Quality Control Engineers to be their guests at their meeting January 24, 1946. This meeting held at the Hotel Statler, heard Alfred Marchev, President of Republic Aviation, Inc., speak on "Simplified Design for Low Cost Airplanes." The meeting was of considerable interest to the members of the Society as many of the factors influencing the low cost production of aircraft are associated so intimately with the control of the quality of the various components and assemblies. The Society gratefully acknowledges the invitation of the Institute of the Aeronautical Sciences to participate in their meeting.

SYLVANIA ELECTRIC PRODUCTS INC.

A single system of Quality Control methods and procedure has been established for those plants engaged in the manufacture of radio receiving tubes and located in the Massachusetts and Pennsylvania areas. Control charts are being maintained for each characteristic of nearly all types of radio tubes manufactured in these plants. The use of control charts has increased very rapidly in the last three months until now they number well over 800. These charts are used not only in connection with quality of the finished product but also with the quality of parts and processes as well. The result is that the Emporium Receiving Tube Plant has taken another step toward better statistical quality control by transferring a portion of Acceptance Control directly to the manufacturing floor. For as many years as special acceptance measurements have been made, the time consumed in making the measurements, transmitting results and recommendations for future action has taken altogether too long. Therefore, the data were late in getting back to the production engineer where they could be used to the best advantage. The method used at present is to take samples of the finished product hourly from the assembly line before any routine inspections have been made so that it is possible to obtain a better picture of processing. A prompt analysis of data has aided already in our ability to make correct decisions immediately thereby eliminating the possibility of manufacture of large quantities of defecitve material. While it is difficult to predict all of the advantages of the new procedure it is believed that the present system will prove extremely helpful and beneficial and with this in mind plans are being made for its continuous expansion.

CURRENT REFERENCE MATERIAL

A page of each issue of the Journal is devoted to titles or brief reviews of articles on Statistical Quality Control appearing in current publications. Earlier issues of the Journal contained bibliographies of materials published in former years. The purpose was to provide readers with a permanent reference list.

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NOTE

Alfred Davis has resigned his position as Chief Inspector of Mechanical Parts at Bausch and Lomb Optical Company, Rochester, New York to accept a teaching and supervisory appointment on the faculty of Rochester Institute of Technology. Edward Close, formerly Assistant Chief Inspector, has replaced Mr. Davis at Bausch and Lomb.

DIMENSIONAL QUALITY CONTROL

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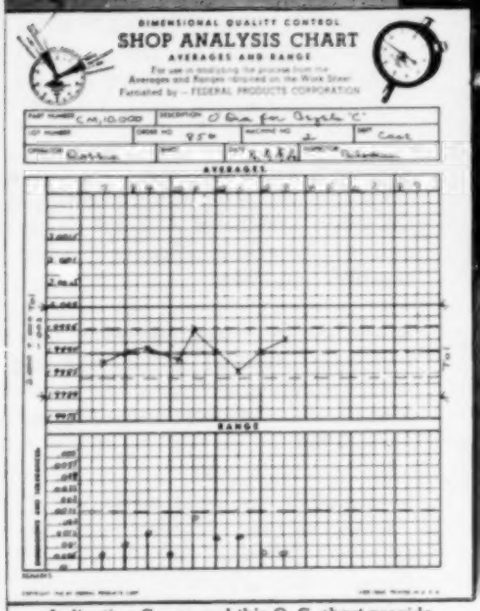

Indicating Gages and this Q. C. chart provide the data and means to keep dimensions under control.

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